

Lunar Dust Life Support and EVA Systems Splinter

Presenters

Joe Kosmo	Apollo Suit History and Data
John Lindsay	Dust Pathways – Forensic Engineering
Bill Farrell	Dust Ingress Probability
Sandra Wagner	Apollo Dust Lessons Learned
John Feighery	Dust Management Overview
Rajiv Kohli	Dust Removal Technology

Outline of Discussion Topics

Spacesuits and sample containers

Space Suit and Sample Container Design for dust control:

1. Prevent dust collection and entrapment
2. Materials that prevent adhesion
3. In-suit dust filters for crew protection
4. Abrasive protection and material coatings
5. Design to prevent dust migration
6. Design for dust tolerant seals
7. Removable/disposable outer garments
8. Suit rotary joints
 - a. Prevent dust ingress & avoid entrapment
 - b. Self-cleaning or cleaning capable
 - c. Abrasion protection
 - d. Seal protection
 - e. Design for performance tolerance to dust
9. Helmet – cleaning and abrasion protection
10. Lights – cleaning and abrasion protection
11. Thermal cooling
12. Suit materials abrasion tolerance

Suit connections (hoses and QDs) design for dust control:

1. Prevent dust ingress into connectors & avoid entrapment
2. Cleaning capable
3. Self-cleaning
4. Abrasion protection
5. Seals protection

System design options and considerations for dust removal prior to ingress:

1. EVA “cleaning station”
 - a. Cleaning of gloves and boots
 - b. Outer garment – legs, arms, and torso
2. Design for cleaning ease
3. Brushes

4. Magnetic removal
5. Electrostatic removal
6. Sticky paper/tape
7. Lay down a barrier cloth or “ground cloth”

Airlock and Ingress Path Design for Dust Control

Design for ease of entry of suited crew vs crawling during Apollo

Additional cleaning and removal inside the airlock:

1. Brushes and/or broom
2. Magnetic and electrostatic removal
3. Sticky paper/materials (tape)
4. Air jets or air shower? (consumable)
5. Retain suits in airlock
6. Suits as crew lock
7. If A/L to crew module hatch, provide positive air flow direction with filters
8. Dust detection on suit and in air
9. Preventing dust ingest into suit after crew doffing
10. “Vibration pad”
11. Separate tools and samples airlock
12. Collection and containment of residue (barrier cloth)
13. Vacuum Cleaner and bag filtration level

Suit maintenance and cleaning inside the Airlock/crew module

1. Suit cleaning, external and internal
2. Suit & PLSS maintenance with dust protection
3. Visor cleaning and protection
 - a. Surface coatings
 - b. Removable coatings
 - c. Abrasive protection external and internal

Crew modules – LSAM, Habitats, CEV & Rover (unpressurized & pressurized)

1. Air flow with filtration
2. Vacuum Cleaner and bag filtration level
3. Positive airflow pattern for mating to between vehicles (CEV, LSAM, Rover, and Hab module)
4. Cleaning of sample containers and any suits carried into crew module
5. Personal Hygiene Methods
 - a. Wash bowl, wash cloths & towels (consumables)
 - b. Wipes
 - c. Magnetic cleaning wand
 - d. Sticky paper/tape
6. Face mask for eyes and breathing filter (odor & dust)
7. Prevention of introduction of dust to suits interior during IVA
8. Dust detection and measurement in cabin air
 - a. At breathing limits
 - b. At Mask removal limits

9. Internal equipment protection and cleaning
 - a. Seals
 - b. Bearings
 - c. QDs
 - d. Electrical connectors and switches

Lunar dust issues in suit and module designs for discussions

1. Methods to prevent dust from entering habitat modules
2. Suit cleaning & maintenance
3. Protection of seals, quick disconnects, hose connectors
4. Protection and cleaning of optical components:
 - a. Radiators
 - b. Visors
 - c. Lights
 - d. Displays
 - e. Photovoltaic arrays
 - f. Windows
 - g. Peel-off optical coatings
5. Technology to detect and measure dust levels in the atmosphere
6. Dust deposition on surfaces and in materials
7. Electrostatic/magnetic interaction with electrical systems
8. Personal hygiene dust removal
 - a. Wash bowl in g-field
 - b. Sticky paper, wet & dry wipes
 - c. Showers, water or air
9. Effects of dust on components & suit thermal properties
- 10.

Need to know or receive:

From Medical:

1. Different dust levels with human exposure time limits
2. Final dust levels for long term exposure
3. Dust mask filtration requirements

From Dust basic research community

1. Dust Particle Size distribution
 - a. Air borne in lunar gravity with time profile for different size ranges
 - b. Non-air borne in lunar gravity
2. Adhesive properties
3. Abrasive properties
4. Magnetic & Electrostatic properties
5. Reactive phase

- a. Materials & atmospheric
 - b. Time to react to an Atmosphere with oxygen and humidity
 - c. Human interaction
 - d. Crew Exposure limits for different levels/sizes
- 6. Flammability/dust flash fire risk
- 7. Dust Simulants for testing
 - a. Identify lunar dust characteristics
 - b. Create simulants to mimic the different characteristics

Potential Dust Mitigation Methods

Strippable coating
Laser Cleaning
Switchable surfaces
Thin film coatings
Magnetic self-cleaning connectors
Electrodynamics screen for dust removal from suits and visors
Magnetic brush
Plasma cleaning of surfaces
Gas brushing
Fibers, textiles and non-wovens technologies
Electrospinning
Wear/damage monitoring
Gecko-inspired fiber adhesive arrays